

PAPER • OPEN ACCESS

Budget optimization modelling for sustainable development of the university research: the example of Russia

To cite this article: Arina Bogomolova *et al* 2018 *J. Phys.: Conf. Ser.* **1117** 012012

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the **collection** - download the first chapter of every title for free.

Budget optimization modelling for sustainable development of the university research: the example of Russia

Arina Bogomolova^{1,2}, Igor Balk², Natalya Ivachenko¹ and Alexandra Terlyga³

¹ Lomonosov Moscow State University, GSP- 1, Leninskie Gory, Moscow, 119991, Russia

² Global innovation Labs LLC, 258 Harvard Str #352 Brookline MA 02446 USA

³ Ural Federal University after the first President of Russia B.N. Eltsin, 61 Komsomolskaya st., Ekaterinburg, Russian Federation.

e-mail: info@innovationlabs.net

Abstract. Russian universities have undergone many changes in recent years, including increased attention to innovative development and transformation of the main function of universities. In addition to education function, universities now should cooperate with the market and create the infrastructure for the successful development of R&D. One of the main resources for this is financing, but it is often in deficiency. Moreover, sudden economic shocks add instability to the situation. This problem is acute for research projects which often last for several years and react sharply to sudden changes in the key resources. This article proposes an optimization model for the management of universities' own funds to ensure sustainable and predictable R&D funding. The model uses mathematical and machine learning methods. The model is applied to statistical data from Russian universities, as well as to one particular Russian university.

1. Introduction

The global reform of education continues in Russia, accompanied by a number of new phenomena and problems. The importance of new technologies and knowledge in the economy increases and turns them into a competitive advantage. Since universities are the main generators and custodians of knowledge, they become the significant factor for further development of innovation environment [1].

In Russia, the development and distribution of education has always been a task of the government. In the Soviet period of a planned and closed national economy, higher education institutions were financed primarily from the Federal budget [2]. However, now there is a tendency to reduce the role of the government in universities development increasing their autonomy [3]. The national priority project "Universities as centers of innovation creation space" [4] provides quite convincing evidence that the government is making significant efforts to ensure modernization and innovative development of the economy. Universities should become one of the key centers of social and economic development of regions [5]. First of all, universities need to expand interaction with the outside world. R&D activity is the first stage in the creation and implementation of new technologies. This is one of the main points of contact between universities and business. To achieve high positions in world



rankings and closer interaction with business, universities need to develop competence in research and development [6].

It is necessary to study one of the main resources for its performance: financing. The problem of this topic is uncertainty, in the conditions of which participants of innovative processes are forced to act, and this is even more relevant for research activities, since as explained in the theory of “three horizons” [7] the projects last an average of several years. Thus, it is necessary to ensure a stable flow of financial resources for the whole research period.

The problem of budgeting in universities has already been a subject for study many times. In recent years, there have been many publications on this topic, for example, authors tried to describe and evaluate the effectiveness of budgeting in China [8], describe empirical models of university budgeting in Europe [9] or problems of implementing a new activity-based budgeting model [10]. All of them agree that budgeting in universities is one of the most important and sophisticated case on which the university's activities are built, which are difficult to accurately value and reform.

This article discusses a narrower topic, namely the financing of only one type of university activities, specifically – R&D. Like all research projects, R&D in universities has a number of problems, for example, opportunistic behavior and the complexity of monitoring. These problems are discussed in more detail in the article of L. Zhang [11]. However, the university faces them in the short term. In this article, we consider the university's strategy of behavior in the long run, where uncertainty becomes one of the main problems. The university receives the biggest share of money from the government, so it depends on it. But state budgets are forming every year anew and the amount of allocated funds for universities can be changed. This can be affected by many factors, for example, the economic situation in the country [12]. The purpose of this article is to build and test a model that will help the university defend against such fluctuations in funding and make it more predictable and sustainable.

2. Methodology and data

In our previous work [13] we have discussed an optimization model for the university R&D budgeting and its application to the US data. This article will focus on the application of the same mathematical model to the Russian data.

Let's discuss the model and data used in this work. We used a constrained optimization model that included an optimization function $F(x)$ with a criterion of the search and a set of constraints [14]. Further, with the help of the machine learning methods, we can discovered a vector of values of the required variables that will satisfy all the constraints and, at the same time, will best fit the search criteria. Such a set of values will be considered optimal and our solution for the problem.

Lets denote a number of the study periods by t and so $i \in [0, t]$ in increments of one year, which is the entire study period.

The main parameter of our interest is R_i – total R&D Funding, which consists of C_i – R&D funding from external sources (industry, federal and others) and U_i – university own funds including U_i^* – resources used in current periods and U'_i – deferred resources for future periods. The latter forms a state variable I_i – investments. So, deferred resources can grow at β – return on investments rate: $I_{i+1} = I_i^*(1+\beta) + U'_i$.

The essence of the model is to find the maximally smoothed and predictable vector of R&D funding resource allocation. Such a target vector is expressed by a variable $R_{i+1}^* = R_i^* (1 + \alpha)$, where α is a constant growth rate. This indicator (α) can be set initially, but we prefer to find the best option.

Thereby, optimization function consists of two search criteria. Thirst is to minimize deviations of the estimated from model values of R&D funding.

$$\min F(U_i) = \sum_{i=0}^t \delta^2 = \min \sum_{i=0}^t (R_i - R_i^*)^2 = \min \sum_{i=0}^t (C_i + U_i^* - R_i^*)^2$$

The second search criterion is to maximize growth rate (α). Thus, this optimization condition is $\max(\alpha)$, which must be performed on par with the $\min F(U_i)$.

Now let's consider constraints. They must be satisfied to have an acceptable solution. They are: $U_i^* \geq 0$ and $U_i^* \leq I_i$. That means that we use only our own funds available to us, which were allocated this year or accumulated in previous years. The solution is represented by U_i – vector of values of University's own funds share used from the budget for R&D activity.

Now we can discuss some more details about the statistical data on Russia that we used with the model. The data on the financing of research activities is administered by the Ministry of Education and Science of the Russian Federation. Annual reports are prepared by the Republican Scientific Research and Consulting Center of Expertise. According to the report, universities receive funding from higher educational institutions, federal as well as foreign sources, extra budgetary funds, funds of private non-profit organizations and their own funds. Values are translated into prices of Russian 2015 rubles using the inflation rate. The open access data exists for the period from 2000 to 2014 [15].

The average indices of the MICEX index (which is the Russian counterpart of the S&P500 index) are used as a benchmark of return on investment, is as a benchmark of the average yield of the market. During its existence, the average value of the index is 17.13%. This indicator will be used as model return on investments rate $\beta = 17.13\%$ [16].

Also the model is applied on the example of one of Russian universities. It is included in the “5-100 program” which is aimed at the raising the most promising Russian universities to the world level. Values will be normalized to maintain confidentiality. Data on the university is available from 2003 to 2017 in the prices of 2017 rubles.

3. Model application on statistics data

The application of the model to statistical data on Russia produced the following results. The sum of the standard deviation is 23.82, which is generally a good result. The optimal growth rate (α) is 16.3%. If we compare the obtained optimal growth rate with the average actual historical growth rate equal to 15.1%, then it turns out that it could be possible to increase the overall growth rate by about 1%. In absolute terms the amount of financing for the period would have increased by 14.74 billion rubles. The lines of the modal (R^*) and estimated (R'') are almost completely coincides. The diagram below (fig. 1) shows an illustration of the application of the model. There are 3 values to analyze: historical (R), model (R^*) and estimated (R'') total R&D funding.

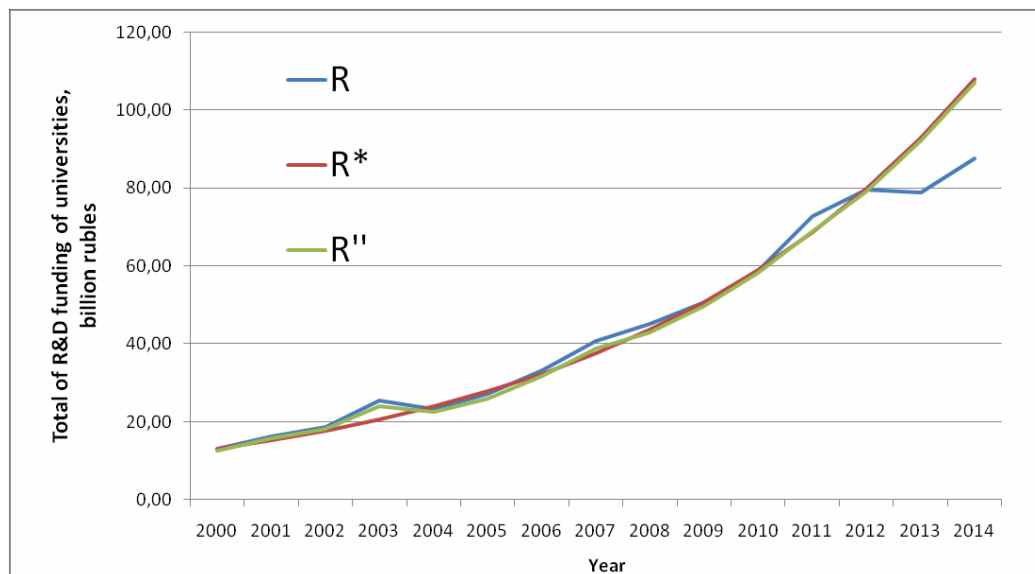


Figure 1. Comparison of the vector of historical total R&D funding (R) with model (R^*) and estimated (R'') under the condition of an optimal growth rate for Russian universities.

Since 2012 there is a sharp decline in the amount of R&D funding. Although the volume of funding from the own funds of Russian universities is small, the competent management of these resources could give a chance to smooth out and compensate for the drop in funding in last years. More clearly, this effect is shown in the following graph (fig. 2). On the left you see a historical change in the share of funding for the resource. As can be seen on the graph, universities only increase funding fluctuations. Moreover, the financing from own funds is insignificant against the background of external sources. However, the optimization model and machine learning offer a different strategy: to accumulate and multiply these low resources in order to use and compensate for funding failures in recent years. As it turned out, even a small amount of own resources is sufficient.

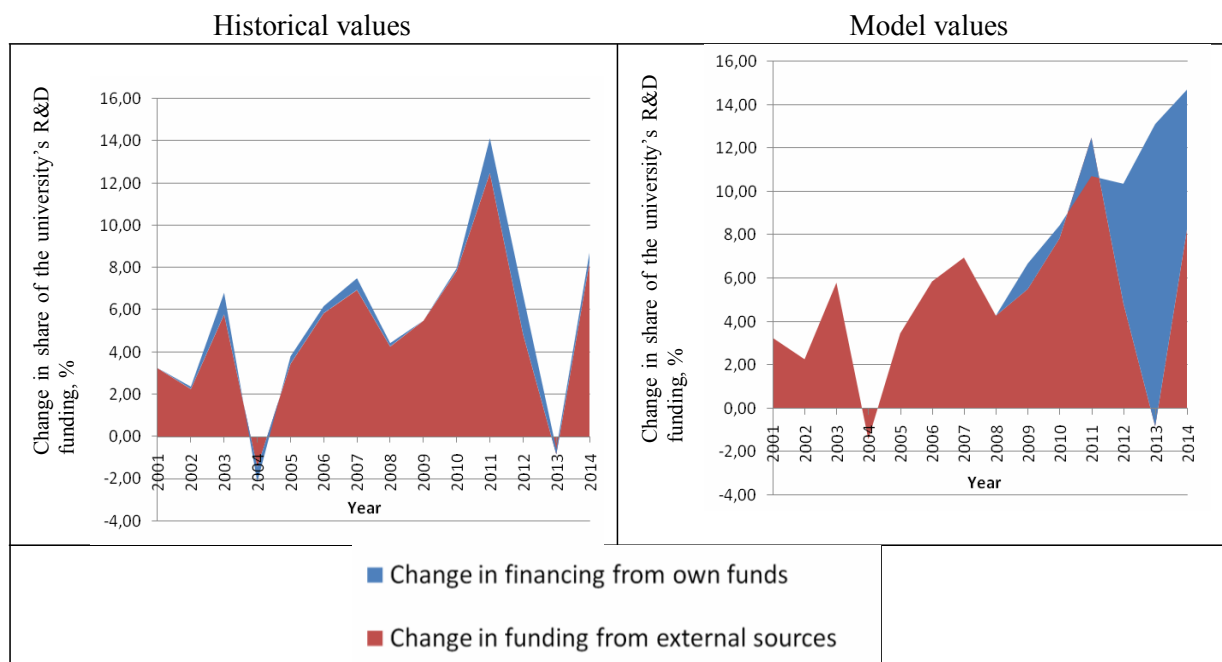


Figure 2. Change in share of the university's R&D funding by sources for Russian universities.

We can see that the investment behavior of Russian universities is far from optimal. Moreover, in order to act optimally, Russian universities lack the so-called "airbag" in the form of some accumulation of their own funds for use in periods of declining funding from external sources.

The next logical step is to test the model on a particular Russian university. Most universities correspond to the average values that we have shown. However, among the most actively developing universities we found one that deserves special attention.

You can see the results below in the graph (fig. 3). This university attracts the interest because, despite the average situation in the country, this university operates optimally. The model confirms that, since the optimal growth rate of financing is 29.02% and the average growth rate (α) is 29%. By the way, this is already an extremely high rate compared with the average for Russia. However, even for this university, the last few years have become financially difficult. Historical and model values do not coincide here, but the reason is a sharp drop of funding from external sources and, although the university increased its own investment, it was not enough to support the previous high level of growth.

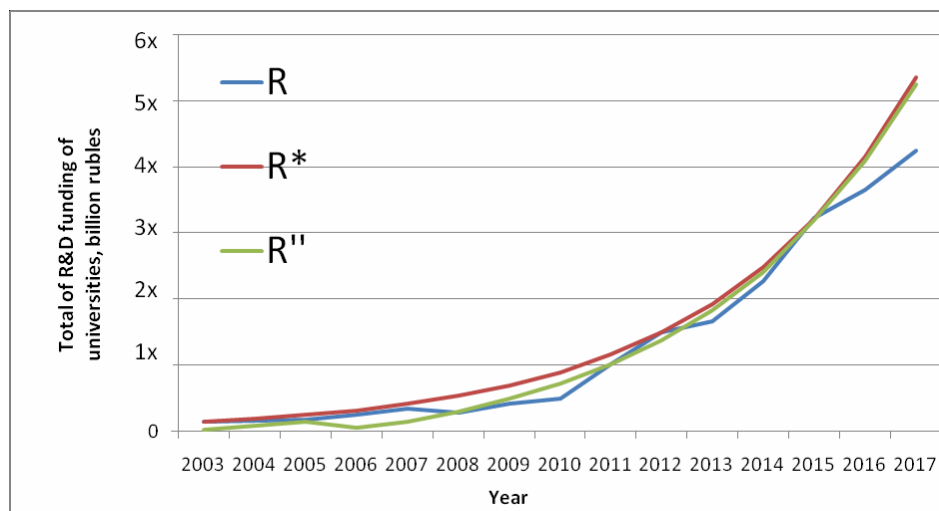


Figure 3. Comparison of the vector of historical total R&D funding (R) with model (R^*) and estimated (R'') under the condition of an optimal growth rate for one of Russian universities.

To confirm the conclusion that the university operates optimally consider changes in R&D funding by source. The graph (fig. 4) below clearly demonstrate that the university operates in opposition to external sources through a graphic contrast of the main extremes. This strategy helps the university smooth out funding and make it more sustainable, even at such a high growth rate.

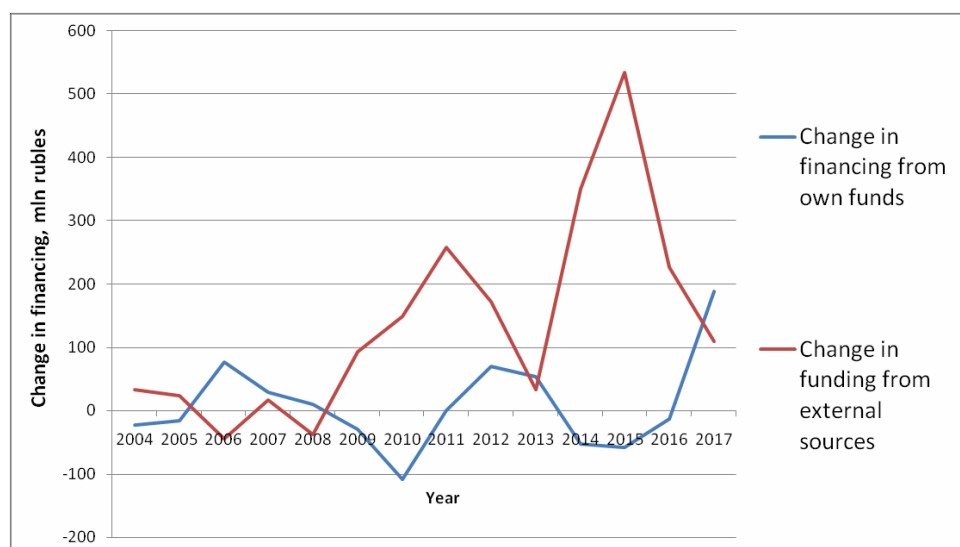


Figure 4. Change in the university's R&D funding by sources for one of Russian universities.

4. Conclusion

Universities play an important role in the development of innovation and as a consequence have new functions. At the same time they face many problems. Financial resources are necessary for the development of research activities, but the problem appears in uncertainty about future periods. The optimization model was applied to solve this problem. The model showed the inadequacy of the Russian universities' own funds to ensure sustainable financing, however, even small amounts of own resources could potentially compensate for the funding gaps in 2013–2014, if properly used. The application of the model to one of the Russian universities, which has high indicators of innovative

development, showed that, despite the overall picture of the country, in Russia there are universities whose actions can be considered optimal.

References

- [1] Etzkowitz H 2008 *The Triple Helix: University-Industry-Government Innovation in Action* (London: Routledge)
- [2] Platonova E 2015 Various Approaches to Financing Russian Higher Education Institutions Integrating into the Global Educational Environment *Procedia Social and Behavioral Sciences* **214** 393–98
- [3] Rutskiy V N and Pyzhov I S 2015 Institutional Problems and Prospects for the Development of Innovative Entrepreneurship in the Resource Economy *Journal of Institutional Studies* **7**(4) 128–37
- [4] The passport of the priority project "*Universities as centers of innovation space*" approved by Presidium of the Presidential Council for Strategic Development and Priority Projects No. 9 of October 25, 2016
- [5] Kitsai U A 2017 Features of the implementation of the concept of entrepreneurial university in Russia *Interactive science* vol. **10** 44–47
- [6] Chernova E G, Akhobadze T D, Malova A S and Saltan A A 2018 Higher Education Funding Models and Institutional Effectiveness: Empirical Research of European Experience and Russian Trends *Issues of education* **3** 37–82
- [7] McKinsey Quarterly 2009 *Enduring Ideas: The three horizons of growth*
- [8] Chen Y T, Liu B and Zhou W 2017 A New Model of Performance Budgeting Management for Local University in China *DEStech Transactions on Social Science Education and Human Science* 272–74
- [9] Seeber M and Lepori B 2017 Budgeting Practices in European Universities *Managing universities: policy and organizational change from a western European comparative perspective* 85–105
- [10] Kenno S A and Sainty B 2017 Revising the budgeting model: challenges of implementation at a university *Journal of applied accounting research* **18**(4) 496–510
- [11] Zhang L, Zhang Z J and Guan X L 2015 Budget Management of University Research Funds: The Perspective Based on Contract Theory 2015 *International conference on logistics, informatics and service sciences* (Barcelona, SPAIN)
- [12] Bogomolova A, Balk I, Ivachenko N, Temkin A, 2017 Impact of the macroeconomic factors on university budgeting the US and Russia *Journal of Physics: Conference Series* **913**
- [13] Bogomolova A, Balk I and Ivachenko N 2017 Budget optimization modeling for sustainable development of the university research: the example of USA *IOP Conference Series: Earth and Environmental Science* **73**
- [14] Arora J S 2005 *Practical Mathematical Optimization: An introduction to basic optimization theory and classical and new gradient-based algorithms* (Springer, Cambridge, Massachusetts)
- [15] Expenditure on research and development and sources of funding: 2016 *Statistics science and education*
- [16] How much does the MICEX Index bring? 2017 *Internet Edition Smart-Lab*